

that, furthermore, when these northerly winds reached the Gulf coast of Texas, the resistances of the land surface being succeeded by the lesser resistances of the waters of the Gulf, they blow with greatly increased force; that, furthermore, this cold air piling up against the precipitous coast of the Gulf of Campeche must give rise to cloudy and, perhaps, rainy weather, and the development of low pressures and cyclonic winds, such that storm centers would start thence and move northeastward toward our Gulf States. The general mechanism of this process is partly exemplified in the MONTHLY WEATHER REVIEW for 1893, pp. 226 and 363, and Chart I for December, 1893.

METEOROLOGY IN COSTA RICA.

The Chief of Bureau is much pleased to learn that after an interregnum of over a year the Government of Costa Rica has taken favorable action with regard to the famous Instituto Fisico-Geografico, and on September 1, 1900, reestablished Prof. H. Pittier as director of that institution, which he founded and conducted for so many years in the interest of all those branches of science and education that constitute the foundations of national prosperity. During the years 1899 and 1900 Professor Pittier was located on the Atlantic coast of Costa Rica, which is very unhealthy as compared with the Pacific coast and the interior, but his return to the good climate of San Jose will, it is hoped, gradually free him from the effects of the pernicious fevers and its resulting mental depression. The printing of the annals, and especially the bulletin of occasional papers, will be resumed at once. Our readers will be pleased to know that a monthly résumé of the conditions in Costa Rica will be communicated promptly for publication in each number of the MONTHLY WEATHER REVIEW. We hope that eventually it may be convenient to publish similar summaries for many other states in the Western Hemisphere.

It is greatly to be hoped that the system of rainfall or climatic stations in Costa Rica may be strengthened by the establishment of new ones in unfrequented localities, and especially by the inauguration of meteorological stations of the first order at Port Limon, on the Caribbean coast, and at some point on the Pacific coast, cooperating with the central station at San Jose, which represents the highlands of the southwestern slope of the central chain of mountains between which and the central chain of Nicaragua lies the valley containing Lake Nicaragua.

MICRO-PHOTOGRAPHS OF SNOW CRYSTALS.

According to an article in the Proceedings of the American Academy, Boston, Mass., April 13, 1898, page 431, by Dr. J. E. Wolff, the collection of about 400 of the most interesting micro-photographs of snow crystals made during the years, 1870-1895, by Mr. W. A. Bentley, of Nashville, Vt., has been acquired at a nominal cost by the Harvard Mineralogical Museum:

The scientific value of the collection is enhanced by Mr. Bentley's notes, and by the meteorological observations made by himself at the time that many of the sets from individual storms were obtained, including date, temperature, snowfall, condition of the clouds, direction and force of the wind, and sometimes notes as to the general character of the snow crystals as the storm progressed.

The magnifications range from 52 to 31 diameters, and are evidently much higher than those of previous collections. The same general types of crystals noticed by previous observers recur here, such as the star form, star form with solid nucleus, and tabular form, while the columnar form (hexagonal prism and base) is rare, and the hexagonal pyramid is not seen. Variations of skeleton growth of hexagonal plates comprising the base and prism of the first order, predominate; less commonly the intermediate axes are visible by lines of growth or

air inclusions, and rarely a triangular development suggests rhombohedral symmetry. The presence of the varied markings due to inclusions of air is much more prominent in these than any as yet published, owing to the higher magnification and the superb technique of the photographs. Mr. Bentley also confirms the previous observation, that large stellate crystals are more common at the higher temperatures and the tabular ones at the lower.

Some photographs of frost crystallizations are included.

This large and perfect collection may justly be called a monument to the patience, skill, and enthusiasm of the maker.

In *A Study of Snow Crystals*, recently published in Appleton's Popular Science Monthly, (May, 1898, pp. 75-82), by W. A. Bentley and G. H. Perkins, the authors give further account of this collection with a reproduction of 27 examples.

The study of the forms of snow crystals has been a favorite subject with many physicists and meteorologists. Prof. Dr. G. Hellmann published in 1893 a little work entitled *Schnee Krystalle*, in which he gives a complete bibliography of the subject and a sketch of the progress of our knowledge, and copies very many diagrams from the older writers: Olaus Magnus, 1555; Descartes, 1637; E. Bartholinus, 1660; R. Hooke, 1665, who first used the magnifying glass and gives more than a hundred forms; F. Martens, 1675, who describes how from a little drop like a grain of sand the crystal grows by accessions from the surrounding fog or cloud until it becomes a hexagonal disk, transparent as glass, and so on, step by step, atom by atom is frozen on to the corners of the disk until it becomes a perfect star—Martens first distinguishes the forms of crystals in their connection with the prevailing weather, as observed by him at Spitzbergen; D. Rossetti, 1681, who distinguishes 6 types among the 60 different forms of snow—some of these types he subdivides into varieties, especially the rosette type, which includes 8 varieties. From this date on the number of publications becomes numerous; we may mention especially the great work of Jan Engelmann, who gives copper plates of 420 forms, although some of these must be considered very doubtful; two editions of this book were published, 1747 and 1771. The first person to form snow crystals artificially was Johann Carl Wilcke, of Sweden, who published two memoirs, 1761 and 1769, in the Transactions of the Royal Academy of Sciences at Stockholm. In 1820, the famous English navigator, Captain William Scoresby, Jr., published 96 snow figures, which have been widely reproduced in works on physics and meteorology. He distinguishes 5 genera, and under these 7 species and many varieties, some of them very rare indeed, near the surface of the earth, but probably more frequent in the upper regions; his 5 varieties have been widely accepted in descriptions of snowflakes, viz: (1) thin plates; (2) flat or spherical nuclei with branches in different planes; (3) fine spiculæ or six-sided prisms; (4) hexagonal prisms; (5) spiculæ having one or both extremities affixed to the center of a lamellar crystal. He also studied the relation of these forms to the weather and the temperature, but subsequently Karl Fritsch, 1853, showed that such relations are quite questionable, and the same result is also arrived at by James Glaisher. The latter observer, 1855, published plates containing 151 snow crystals, most of which are idealized pictures more delicate and symmetrical than is ever found in nature. It was the study of Glaisher's work that led Dr. Hellmann to pursue his investigations and, eventually, to apply micro-photography to the preservation of these fleeting forms. We ought, perhaps, to add that, among American observers, one should be put on record, Mrs. F. E. Chickering, of Portland, Me., who published a work anonymously entitled *Cloud Crystals, A Snowflake Album*, New York, D. Appleton & Co., 1864, reproducing on 27 plates original drawings, made between 1857 and 1863, of 189 forms observed at Portland, Me. This work contains also interesting communications on this subject by Prof. Louis Agassiz,

Cambridge, and Dr. Charles Smallwood, of Montreal. Among other items, Mrs. Chickering notes that twice she has observed the rare forms of hexagonal plates and hexagonal axles or prisms joined together in various combinations, like wheels and axles. Some of her figures were copied while in a deliquescent state, and some of her forms would, she says, be probably rejected by science as being in a transition state, but, as she correctly remarks, even in their transitions they are as much under law as when fixed. Unfortunately the dates and general weather conditions are not fully given in this volume.

All preceding work was done with the hand, aided by the microscope, but Professor Hellmann reproduces the microphotographs taken by Dr. Neuhauss at Berlin, in 1892-3, at the request of Dr. Hellmann. These pictures show the immense variety of types and variations under the types that occur in nature, as well as the great irregularity or departure from ideal forms sketched by previous observers. The angles 60° are preserved everywhere, but the combinations of parts are innumerable. Hellmann notices many peculiarities in the crystals from a crystallographer's point of view. With regard to the structure of the crystal, he finds as the most remarkable point the fact that the principal and subordinate rays are hollow capillary tubes. This fact had been known hitherto in only one special form of snow crystal, but the microphotograph shows that it exists everywhere. After the publication of a notice of Hellmann's work, other works were published confirming this structure, such as that of G. Nordenskiöld, in Stockholm, published by the geological society in that city, and he also recognizes it in the careful drawings published by Rossetti in 1881. Hellmann finds that the purely star-formed snow crystals on the average are larger than those that have the shape of 6-sided plates, in the ratio of 2.8 to 1.9, as deduced from his early observations, and in the ratio of 2.3 to 1.3 from the microphotographs. As regards the connection with temperature, Scoresby showed that crystals were more delicate and thinner and, in general, smaller as the cold increased. Hellmann finds that at -10°C . they are but one-third the size of those at -2°C . The microphotographs show the following mean diameters as the average of 6 to 10 cases: 3.4 millimeters at -6°C .; 2.2 mm. at -8°C .; 1.2 mm. at -12°C . He notes that the diminution in the weight of aqueous vapor per cubic meter in saturated air proceeds in very much the same ratio, viz: 3.2 grams for -6°C .; 2.7 grams at -8°C .; 2.0 grams at -12°C ., and 0.5 grams at -30°C . The number of cases of occurrence of the different types of crystals also depends upon temperature, but the connection is not yet at all certainly made out; nevertheless the prevailing types occur in the following relative frequencies:

Relative frequency of snow crystals.

Forms of crystals.	Temperature.	
	-6° to -7.5°	-9° to -12.5°
	Per cent.	Per cent.
1. Stars with rays	52	24
2. Stars with flat expansions	22	19
3. Flat plates	26	57

From this we may conclude that the frequency of the flat forms increases, and that of the stellate forms diminishes with diminishing temperature, while the intermediate form, 2, occurs with equal frequency.

Hellmann finds the following classification adapted to his own observations. Type 1, lamellar snow crystals subdivided into (a) stars with rays; (b) flat plates, and (c) combinations of (a) and (b). Type 2, columnar snow crystals subdivided into (a) prisms; (b) pyramids and (c) combinations

of (a) and (b). The type 1 is that usually observed both in temperate and polar regions.

Soon after the publication of Hellmann's work, in 1893, he discovered that not only Nordenskiöld, at Stockholm, but also A. A. Sigson in Rybinsk, Russia, had been making microphotographs, some of which Hellmann reproduces in the *Meteorologische Zeitschrift*, 1894, p. 281, as these were the largest and most perfect yet attained. If to these three European collections we add the still larger collection made by W. A. Bentley during the years 1870-1895, it would seem that we have material for a very complete study of the forms and methods of formation of the snow crystal. But at present there does not seem to be much prospect of deriving from this study any additional knowledge of the temperature, moisture, and pressure prevailing when they are formed. It seems to the Editor much more likely that the small amounts of other gases and vapors occasionally present in the atmosphere, or the nature of the nuclei around which the crystals form, or the transitions through which they pass as they recrystallize while descending to the earth, may have a greater influence on their forms than pressure, moisture, and temperature.

BOMBARDING HAIL CLOUDS.

In answer to numerous inquiries about shooting at hail clouds for the purpose of dispersing them, the Editor would state that although statistics show that during the past year 15,000 shooting stations were established in Italy and a very large number in southern France and Austria, yet there is no evidence whatever that the shooting done by these stations has had any effect whatever upon the hailstorms or the hail. Generally the quantity of powder used is so small that the vortex rings are not able to ascend farther upward than 1,000 feet. They do not, therefore, reach the clouds; and if any effect could be produced upon the hail, it could only be by virtue of the noise or the dust, and these are far less than those made by Dyrenforth in his experiments with dynamite in 1892. The very sensible report of the director of the agricultural societies of the southeast of France says:

We cannot conclude that the use of cannon will always afford complete protection, but it is undeniable that the results obtained are very interesting.

The recent congress of hail-shooters at Padua (25-29th November, 1900), could only conclude that we are in the midst of an extensive experiment, and that several years' work will be required in order to ascertain the true effect of the cannonading.

In some parts of France for several centuries it has been the custom to ring the church bells when a hailstorm is approaching. The modern newspaper writer guesses that the people do this by reason of their belief in the efficacy of the sound of the bell; but the historical fact is that this was originally simply an invitation to all good churchmen to unite in prayer for deliverance.

There is no doubt that the cannonading is believed to be effectual by the farmers who do the work; otherwise, they would hardly continue the labor and expense; and yet we must remember that waves of irrational enthusiasm sometimes sweep over a community only to be regretted in subsequent years, when a calmer judgment has come to prevail. The fact that 10,000 or 20,000 shooting stations have been established is of itself no argument as to the efficacy of the process. One might as well argue that the moon really affects the weather because a million people believe it, and can prove it—to their own satisfaction. A knowledge of the exact truth on any question of natural science is not easily attained, else the world would long since have progressed far beyond its present status in knowledge and civilization. The